

What is claimed is:

1. A method for determining a desired biologic constituent concentration of the blood of a patient, the blood flowing in a pulsatile fashion in a body part of the patient so as to be subjectable to transcutaneous examination in the body part, the body part defining a blood conduit and the method comprising the steps of:
  - (a) placing the blood conduit within a blood conduit receiver with the blood flowing in the blood conduit;
  - (b) directing radiation into the flowing blood within the blood conduit using a radiation generator situated within said blood conduit receiver means, said radiation defining a directed radiation comprising a first quantity of radiation at a radiation wavelength which, when directed into the flowing blood within the blood conduit,
    - (A) has a first attenuation value which varies with the desired biologic constituent concentration in the flowing blood and
    - (B) has a second attenuation value which varies with the concentration of components other than the desired biologic constituent in the flowing blood, which second attenuation value is at least ten times smaller than said first attenuation value, and
  - (c) detecting the portion of said directed radiation which passes through both the blood conduit and the flowing blood therein using a radiation detector situated within said blood conduit receiver, said detected portion of said directed radiation comprising a second quantity of radiation at the radiation wave length; and

- (d) detecting energy from the flowing blood within the blood conduit using an energy transducer situated within said blood conduit receiver, said energy defining a transduced energy comprising a quantity of energy which when detected from the flowing blood within the blood conduit, has a value which varies with the normalized change of the pulsatile blood; and
- (e) operating exclusively on the second quantities of the radiation and the transduced energy to determine the desired biologic constituent concentration.

2. A method as defined in claim 1, wherein the step of detecting the second quantity of the radiation wavelength comprises the steps of:

- (a) determining the intensity of the total radiation wavelength; and
- (b) determining a radiation wavelength pulsatile value representing the intensities of a pulsatile component of the radiation wavelength at discreet time intervals during the pulse.

3. A method as defined in claim 1, wherein the step of detecting the transduced energy comprises the steps of:

- (a) determining the electronic signal generated from the transduced energy; and
- (b) determining a transduced energy pulsatile value representing the intensities of a pulsatile component of the transduced energy at discreet time intervals during the pulse.

4. A method as defined in claim 1, wherein the step of operating exclusively on the second quantities of the radiation at the radiation wavelength to determine the desired biologic constituent concentration of the patient comprises the steps of:

- (a) mathematically operating on the second quantities of the radiation wavelength such that the time derivative of the pulsatile intensities is normalized by the average intensity over the pulse interval followed by a distance derivative of that quantity to produce a value proportional to  $\partial\alpha/\partial t$ ; and
- (b) mathematically operating on the second quantities of the radiation wavelength such that the logarithm of the intensity is distance differentiated to produce the value  $\alpha$ .

5. A method as defined in claim 1, wherein the step of operating exclusively on the transduced energy comprises the step of performing the time derivative of the normalized pulsatile transduced energy to obtain the value  $\partial X_b/\partial t$ .

6. A method as defined in claim 1, wherein the step of operating exclusively on the second quantities of the radiation and the transduced energy comprises the step of mathematically solving the relationship  $K_b = B \cdot (\alpha \cdot \partial\alpha/\partial t) / (\partial X_b/\partial t)$  with a polynomial function or empirically determined value.

7. A method as defined in claim 1, wherein the desired biologic constituent comprises hematocrit or hemoglobin.

8. A method as defined in claim 1, wherein the first attenuation value is substantially the same amount for oxyhemoglobin and for reduced hemoglobin in the flowing blood and the second attenuation value is at least ten items smaller than said first attenuation value for any competing constituent in the flowing blood.

9. A method as defined in claim 1, wherein the radiation wavelength is in the range from about 790 nanometers to 850 nanometers.

10. A method as defined in claim 1, wherein the radiation wavelength is in the range from about 550 nanometers to 600 nanometers.

11. A method as defined in claim 1, wherein the energy transducer means is a pressure transducer element, a strain gage element, a piezo electric film element, or a doppler detection element.

12. A method for determining a desired biologic constituent concentration of the blood of a patient, the blood flowing in a pulsatile fashion in a body part of the patient so as to be subjectable to transcutaneous examination in the body part, the body part defining a blood conduit and the method comprising the steps of:

- (a) placing the blood conduit within a blood conduit receiver with the blood flowing in the blood conduit;
- (b) directing radiation into the flowing blood within the blood conduit using a

radiation generator situated within said blood conduit receiver, said radiation defining a directed radiation comprising:

- (i) a first quantity of radiation at a radiation wavelength which, when directed into the flowing blood within the blood conduit,
  - (A) has a first attenuation value which varies with the desired biologic constituent concentration in the flowing blood and
  - (B) has a second attenuation value which varies with the concentration of components other than the desired biologic constituent in the flowing blood, which second attenuation value is at least ten times smaller than said first attenuation value, and
- (ii) a first quantity of a radiation at a second radiation wavelength, distinct from said first wavelength, which, when directed into the flowing blood within the blood conduit,
  - (A) has a third attenuation value which for varying concentrations in the flowing blood of the desired blood constituent is a non-fixed multiple of said first attenuation value; and
  - (B) has a fourth attenuation value which varies with the concentration of components other than the desired biologic constituent in the flowing blood, which fourth attenuation value is at least ten times greater than said second attenuation value;

(c) detecting the portion of said directed radiation which passes through both the blood conduit and the flowing blood therein using a radiation detector situated within said

blood conduit receiver, said detected portion of said directed radiation comprising:

- (i) a second quantity of a radiation at the first radiation wavelength and,
- (ii) a second quantity of a radiation at the second radiation wavelength;
- (d) detecting energy from the flowing blood within the blood conduit using an energy transducer situated within said blood conduit receiver, said energy defining a transduced energy comprising a quantity of energy which when detected from the flowing blood within the blood conduit, has a value which varies with the normalized change of the pulsatile blood; and
- (e) operating exclusively on the second quantities of the radiations and the transduced energy to determine the desired biologic constituent concentration.

13. A method as defined in claim 12, wherein the step of operating exclusively on the transduced energy comprises the step of performing the time derivative of the normal pulsatile transduced energy of the second radiation wavelength as defined in claim 19 to obtain the value  $\partial X_2 / \partial t$ .

14. A method as defined in claim 12, wherein the step of operating exclusively on the second quantities of the radiation and the transduced energy comprises the step of solving the relationship  $f(H) = G \cdot (\alpha \cdot (\partial \alpha / \partial t))$  first /  $(\alpha \cdot (\partial \alpha / \partial t))$  second with a polynomial function or empirically determined value.

15. A method for determining a desired biologic constituent concentration of the blood

of a patient, the blood flowing in a pulsatile fashion in a body part of the patient so as to be subjectable to transcutaneous examination in the body part, the body part defining a blood conduit and the method comprising the steps of:

- (a) placing the blood conduit within a blood conduit receiver with the blood flowing in the blood conduit;
- (b) directing radiation into the flowing blood within the blood conduit using a radiation generator situated within said blood conduit receiver, said radiation defining a directed radiation comprising a first quantity of a radiation at a radiation wavelength which, when directed into the flowing blood within the blood conduit,
  - (A) has a first attenuation value which varies with the desired biologic constituent concentration in the flowing blood and
  - (B) has a second attenuation value which varies with the concentration of components other than the desired biologic constituent in the flowing blood, which second attenuation value is at least ten times smaller than said first attenuation value;
- (c) detecting the portion of said directed radiation which passes through both the blood conduit and the flowing blood therein using a radiation detector situated within said blood conduit receiver, said detected portion of said directed radiation comprising a second quantity of radiation at the radiation wavelength; and
- (d) detecting energy from the flowing blood within the blood conduit using an energy transducer situated within said blood conduit receiver, said energy defining a transduced energy comprising a quantity of energy which when detected from the

flowing blood within the blood conduit, has a value which varies with the normalized blood volume; and

- (e) operating exclusively on the second quantity of the radiation and the transduced energy to determine the desired biologic constituent concentration.

16. A method as defined in claim 15, wherein the step of operating exclusively on the transduced energy comprises the step of measuring the transduced energy when the blood conduit is blood-filled, then later made blood-less in order to obtain the value  $X_b$ .

17. A method as defined in claim 16, wherein the step of determining  $X_b$  is accomplished by solving  $1 - (V_o/V_f)$  with the above energy transducer means.

18. A method as defined in claim 17, wherein the step of determining  $V_o/V_f$  is accomplished by solving  $(V_o/V_f) - 1$  with a polynomial function of the pressure transducer element.

19. A method for determining a desired biologic constituent concentration of the blood of a patient, the blood flowing in a pulsatile fashion in a body part of the patient so as to be subjectable to transcutaneous examination in the body part, the body part defining a blood conduit and the method comprising the steps of:

- (a) placing the blood conduit within a blood conduit receiver with the blood flowing in the blood conduit;

(b) directing radiation into the flowing blood within the blood conduit using a radiation generator situated within said blood conduit receiver, said radiation defining a directed radiation comprising:

(i) a first quantity of a radiation at a radiation wavelength which, when directed into the flowing blood within the blood conduit,

(A) has a fifth attenuation value which greatly varies with the nondesired biologic constituent concentration in the flowing blood and

(B) has a sixth attenuation value which varies with the concentration of the desired biologic constituent in the flowing blood, which second attenuation value is at least ten times smaller than said fifth attenuation value, and

(ii) a first quantity of a radiation at a second radiation wavelength, distinct from said first wavelength, which, when directed into the flowing blood within the blood conduit,

(A) has a seventh attenuation value which for varying concentrations in the flowing blood of the nondesired blood constituent is a multiple of said fifth attenuation value;

(B) has an eighth attenuation value which varies with the concentration of the desired biologic constituent in the flowing blood, which eighth attenuation value is at least five times greater than said sixth attenuation value;

- (c) detecting the portion of said directed radiation which passes through both the blood conduit and the flowing blood therein using a radiation detection means situated within said blood conduit receiving means, said detected portion of said directed radiation comprising:
  - (i) a second quantity of a radiation at the first radiation wavelength, and
  - (ii) a second quantity of a radiation at the second radiation wavelength;
- (d) detecting energy from the flowing blood within the blood conduit using an energy transducer means situated within said blood conduit receiving means, said energy defining a transduced energy comprising a quantity of energy which when detected from the flowing blood within the blood conduit, has a value which varies with the normalized change of the pulsatile blood; and
- (e) operating exclusively on the second quantities of the radiations and the transduced energy to determine the desired biologic constituent concentration.

20. A method for determining a desired biologic constituent concentration of the blood of a patient, the blood flowing in a pulsatile fashion in a body part of the patient so as to be subjectable to transcutaneous examination in the body part, the body part defining a blood conduit and the method comprising the steps of:

- (a) placing the blood conduit within a blood conduit receiver means with the blood flowing in the blood conduit;
- (b) directing radiation into the flowing blood within the blood conduit using a radiation generator situated within said blood conduit receiver, said radiation

defining a directed radiation comprising a first quantity of a radiation at a radiation wavelength which, when directed into the flowing blood within the blood conduit,

- (A) has a first attenuation value which varies with the desired biologic constituent concentration in the flowing blood and
- (B) has a second attenuation value which varies with the concentration of components other than the desired biologic constituent in the flowing blood, which second attenuation value is at least ten times smaller than said first attenuation value;

- (c) detecting the portion of said directed radiation which passes through both the blood conduit and the flowing blood therein using a radiation detector situated within said blood conduit receiver, said detected portion of said directed radiation comprising a second quantity of a radiation at the radiation wavelength; and
- (d) detecting energy from the flowing blood within the blood conduit using an energy transducer situated within said blood conduit receiver, said energy defining a transduced energy comprising a quantity of energy which when detected from the flowing blood within the blood conduit, has a value which varies with the normalized change of the pulsatile blood;
- (e) operating exclusively on the second quantities of the radiations and the transduced energy to determine the desired biologic constituent concentration by qualifying the tissue's homogeneity from the linearity of the distance differentiation.

21. A method as defined in claim 20, wherein the step of operating exclusively on the

second quantities of the radiation at the radiation wavelength to determine the desired biologic constituent concentration of the patient comprises the steps of:

- (a) mathematically operating on the second quantities of the radiation wavelength such that the time derivative of the pulsatile intensities is normalized by the average intensity over the pulse interval followed by a distance derivative of that quantity to produce a value proportional to  $\partial\alpha/\partial t$ ;
- (b) mathematically operating on the second quantities of the radiation wavelength such that the logarithm of the intensity is distance differentiated to produce the value  $\alpha$ ;
- (c) mathematically determining the linearity and deviation of the logarithm of the intensity and the  $(\partial i/\partial t)/i$  values versus distance; and
- (d) mathematically decoupling, isolating, and determining the individual constituent absorptive and scattering coefficients from the homogeneity qualified  $\alpha$ ,  $\partial\alpha/\partial t$  and  $\partial X_b/\partial t$  values.